1.0 PROJECT PURPOSE

Fire is a significant part of wildland ecology in southern California, a natural event that has been repeated on these landscapes for eons (Mensing et al. 1999). As early as 1889, massive fires, sometimes 100 miles wide and traveling 10-15 miles (Los Angeles Times, September 26, 1889), were described by early residents in shrubland communities of the backcountry. These huge fires are typically fueled by Santa Ana winds in the autumn. Hot gusts of air off the continent descend to the coast, achieving speeds of 50-60 mph and careening over mountains and valleys already dry from summer drought. In the heart of this fire landscape, lie the urban and agricultural developments of one of the most rapidly growing areas in the United States. Since the late 1800s, the population in the region has grown 30 fold and, in Riverside and San Diego counties alone, over 2,000 miles of wildland-urban interface have been created (Scott 1995). Many of these areas receive the highest fire hazard ranking bestowed by the California Department of Forestry and Fire Protection due to rugged terrain, the occurrence of natural vegetation communities, and climatological conditions (i.e., Santa Ana winds) described by fire climatologists as the most hazardous in the nation.

The 2003 October wildfires, fueled by Santa Ana winds, were the single worst disaster in California's history, exceeding devastation of all previous fires, earthquakes and other natural disasters. At the culmination of the siege, 14 fires in 6 counties consumed over 750,000 acres of wildlands, destroying 3,338 residential structures, 33 commercial properties, 1,072 outbuildings, and claiming the lives of 26 people. The conflagration caused the greatest mobilization of firefighting resources in California's history. All told, federal and local price tabs totaled $3 to $5 billion.

After the 2003 fires, local and regional "think tanks" began the challenging task of understanding the factors leading up to this event and what actions could be taken to minimize damages and losses caused by the next fire. While management activity and policy cannot prevent future fires, these groups found that much more can be done to reduce the impact of fires on property and lives. Their recommendations include new policies and regulations, increasing the effectiveness of education programs, and enhancing management, prefire, and response activities. The use of new technologies was highlighted as an important area for future growth. Specifically, the State Blue Ribbon Commission, the 2003 Wildfire Summit, and others issued recommendations to incorporate advanced technologies to address wildfire response and education in new and innovative ways.

We propose to demonstrate how existing sensor technology and broadband networks can be used to facilitate an environment of community preparedness and improved fire response. In this proposal, universities (San Diego State University Field Station Programs, SDSU Visualization Center, and the Scripps Institute of Oceanography), the community of Fallbrook (Fallbrook Fire Safe Council and Mission Resource Conservation District), fire response agencies (California Department of Forestry and Fire Protection and North County Fire Protection District), and business (Ambient Control Systems) are joining forces to install an early-warning fire detection and hazard assessment network in a severe fire hazard area at the wildland-urban interface in San Diego and Riverside counties near the town of Fallbrook. This collaborative multi-organizational project integrates new sensor technology, existing broadband networks, and an educational program to demonstrate the ability of new technologies to quickly locate fire and improve and maintain public awareness and preparedness. We propose to: (1) install an array of 13 state-of-the-art wireless fire detection sensors, 3 weather stations, and 4 remote cameras that serve as sentinels for early fire detection and localization and fire hazard conditions on an existing broadband network at the wildland/urban interface; (2) deliver this information through pagers and a web-based interactive map to the California Department of Forestry and Fire Protection (CDF) Emergency Command Center; and (3) implement a community-wide fire education program that uses the interactive website to build public awareness and preparedness. This project will merge new and existing technologies to develop a fire-awareness communication system that builds long-term partnerships between fire response agencies, community members, and resource managers.

Project Area - Fallbrook serves as an ideal backdrop for the deployment of a wireless fire sensor network. Fallbrook is a rural, agricultural community of approximately 39,000 residents that lies within “very high hazard severity zone” (California Department of Forestry fire rating danger system). Chaparral and other shrublands, the most common fuel types in the October 2003 fires, dominate rugged and often inaccessible terrain surrounding the community. Between 1996 and 2001, Fallbrook’s 92-mi^2 North County Fire Protection District averaged 31 vegetation fire calls per year. Common causes of fire ignitions include agricultural burns, sparks from cars on roadways, off-road vehicles, and inappropriate use of backyard equipment.

Just north of town, the Santa Margarita Ecological Reserve (SMER), a 4500-acre field station, has a 20-year history of supporting research and education on natural ecosystems. The reserve operates a state-of-art wireless broadband network that streams data from sensors (e.g., cameras, thermometers, flow meters, sound, etc.) located over 2/3 of the reserve’s rugged backcounty areas. Through its Memorandum of Understanding with California Institute of Technology and Telecommunication, and support of regional telecommunication projects, the field station serves as a demonstration site for applying new technologies to study environmental phenomena.

In February 2002, the Fallbrook community suffered its own devastating fire losses. Strong Santa-Ana winds transformed embers from an “extinguished” agricultural burn into a firestorm, destroying 47 homes (most during the first hour) and burning over 5,000 acres. The Gavilan fire highlighted key problems identified one year later by post-Oct 2003 “think tank” groups. Due to rugged terrain and poor access, fire fighters were unable to locate the fire based on descriptions from homeowners, causing crucial delays and catastrophic results. In addition, homeowners in the area were unprepared for wildfire emergency and few had made recommended fire safety modifications to their homes to reduce the risk of burning.

Solutions and Outcomes – After the 2002 Gavilan Fire, local community members established the Fallbrook Fire Safe Council to address fire awareness and preparedness through neighborhood fire prevention forums, sponsored community events, and collaborative management projects. Hearing about new advance in fire sensor technology, the Fire Safe Council approached SMER to explore ways to build upon the community’s desire for improved fire safety through technological innovations already deployed at the reserve. Together they began working with fire response agencies, university, and community partners to develop a fire awareness communication system that could uniquely address resource management and community safety issues by using advanced sensor technology and broadband wireless telecommunication.

Our consortium proposes to install an array of fire sensors, weather stations, and remote cameras onto an existing broadband wireless network at SMER (Appendix Figure 1). Data streaming from these sensors will be made available to 24-hour emergency staff at the California

Department of Forestry and Fire Protection's Emergency Command Center and the North County Fire Protection District, and will identify fire location, weather conditions, and provide real-time video images of the area. This wireless network of sensors will quickly and reliably locate fire and fire hazards at the wildland-urban interface. The installation, cost, maintenance, speed, and reliability will be clearly documented on our website for others interested in installing similar detection networks.

We will support end-users using the system by implementing a community fire education program that explores the ability of real-time sensor technology to attract and motivate homeowners regarding risk and preparedness. Our community program (see Appendix) builds on the successes and lessons from other community education efforts and recognizes the importance of engaging a broad base of neighborhood activists, community leaders, businesses, and elected officials (Hodgson 2003). The outcome of the community education program will be an increase in community awareness and preparedness that is enhanced by the fire sensor network. Our program will be the first fire education program to use real-time sensors and broadband technology to establish a long-term communication system among the community, fire response agencies, and resource managers that enhances fire safety.

2.0 INNOVATION

Our innovative approach relies on commercially available technologies. We propose to purchase the newly available Ambient FireAlert sensor, the only commercially available sensor capable of detecting fire in remote backcountry (see Appendix for photos and additional description). The sensor has low-energy use platform and standalone internal solar power supply. Embedded smart processing detects carbon dioxide emissions from wildfire (less than 8 x 8 feet in size within ½ mile) over a 360° field of view in less than 2 minutes. This level of sensitivity makes them ideal for early-warning situations. The significance of a long-lived (the manufacturer estimates a 20-year lifespan for the sensor) sensor capable of scanning and reporting on infrequent fires in remote areas has enormous implications for wildfire detection and response, replacing efforts originally covered by fire-lookout personnel and providing accurate map-based reports of fire location, potentially saving property and lives.

The sensors will be installed on the existing 802.11b broadband sensor network at SMER to monitor areas with a high risk of ignition. SMER is the only field station in North America that provides a large-scale 802.11b wireless network across over 3200-acres of remote rugged terrain. While the FireAlert sensors are also satellite-ready and can be installed in any area with satellite coverage, the existing wireless network as SMER provides a unique solution for demonstrating the capabilities of a fire network: (1) Internet connectivity is provided at no cost and provides long-term monitoring capabilities once the components are installed, and (2) other sensors, such as cameras and weather sensors, can be used to augment awareness of the fire sensor network and function via the website, and (3) a variety of data from existing projects at the field station data files are available for developing interactive media on the website.

Two other groups are currently in process of purchasing and installing Ambient FireAlert sensors: the U.S. Forest Service in Colorado and the small historic community of Deadwood in South Dakota. While we will coordinate and communicate with these efforts, our project differs in several ways: (1) our sensors will be placed to maximize early-warning capabilities over a 5-mile band of contiguous coverage in high-risk ignition areas north of Fallbrook: along Interstate 15 where 3 fires have started in the last 3 years, and adjacent rural cluster of homes and agriculture. (2) We will demonstrate fire detection in the landscape in which the southern

California fires raged: shrublands in rugged terrain with obstructed field of views. (3) We will make sensor outputs available as part of a community education program. Our project will be the first to demonstrate how real-time sensors can be used to educate the public and determine its effectiveness in holding public attention and motivating homeowners to take action.

3.0 COMMUNITY INVOLVEMENT

The partners on our project have a history of working together and with Fallbrook community members on a variety of projects, including using new sensor technology to study environmental phenomena and a fire management planning effort funded by FEMA Hazard Mitigation Grant Program. This project will unite those efforts and provide us with an opportunity to further our collaborations to benefit our local community. Here we provide a brief description of the contributions made by each our partners to this project: (1) SDSU Field Station Programs will provide matching salary for project oversight, maintaining the wireless network, housing for interns, administrative specialist support, GIS assistance, and trail maintenance; (2) the SDSU Visualization Center has graciously agreed to provide a server with ultra-high capacity Internet service (2GigE) as the host for the web-based display of the sensor network, matching salary for promoting the project to agencies, and volunteer student time for working with the data; (3) Scripps Institute of Oceanographic Research will provide equipment for 4 weather stations and matching salary for installation and setup of the data streaming equipment, (4) The Fire Safe Council will provide volunteer time from Board Members and community members for the education program, (5) Mission Resource Conservation District will provide a wealth of expertise working with the community and office space for the educational program; (6) California Department of Forestry and Fire Protection (CDF) and North County Fire Protection District have offered personnel for technical training sessions and community events and will identify the web page as a resource for determining fire location during an emergency. (7) Ambient Control Systems is offering a 30% reduction in FireAlert sensor costs, 17% reduction in receiver costs, and is providing mounting hardware and technical assistance. For additional information regarding our missions and accomplishments, please see the Appendix. Letters of support for the project are provided with the Statement of Matching Funds.

Support for End Users

End users of the project are emergency response staff at CDF and North County FPD and public in the community of Fallbrook and potentially a variety of other communities that might benefit from the technologies demonstrated in this project. Website displays for emergency personnel will be simple and information rich. When the sensor network detects a fire, the data server at SMER will send a message via pagers to personnel at the CDF Emergency Command Center and emergency response personnel at North County FPD. Personnel will immediately log in via the Internet to the webpage on the SDSU Visualization Center server which has also been notified to go into emergency mode – displaying only information pertinent to a fire emergency. A map of the region surrounding the fire network will show the location of the fire, significant weather conditions (i.e., wind speed and direction, fuel moisture and temperature) for weather stations in the project area, and visual images of the area. Technical updates and training sessions for CDF and North County FPD staff will be provided by the Technical Director and will occur at least once per year after the website is running.

The interactive web-site for the public will contain a rich variety of information and activities. Foremost among these is the real-time fire hazard model. We will “personalize” fire hazard by presenting the model output on maps that allow community members to identify the location of their homes relative to the fire hazard zones. Changes in fire hazard models outputs will provide community members with a better understanding of the continuing danger. Visitors to the site will also be able to view maps, images and operational status of the sensor network, 3-D visualizations of the topography and landscape, and fire hazards and Santa Ana wind condition summaries for the year.

Community members will be introduced to the website through the Community Education Program, lead by the Fallbrook Fire Safe Council and Mission Resource Conservation District. In addition to observing the fire sensor network and real-time hazard conditions, community members will be able to download how-to manuals for fire preparedness, fire facts, flyers and other educational materials. During a fire, the website will serve as a one-stop information center where the public can obtain information about where to get information regarding the fire, evacuation routes, and, if available, fire location on the sensor network. Development of the website will be an iterative process, where the community will contribute to website development, specifically tailoring webpages to meet their needs.

4.0 EVALUATION

Evaluation of this fire detection and community fire education program will determine the efficacy of the specified components of the project. Our evaluation will focus in two areas: (1) the accuracy and usability of the fire detection sensor network, and (2) the effectiveness of the community-based fire preparedness program.

Fire Detection Sensor Network

The technological portion of the evaluation plan will address whether fire sensors and network technology can be used to quickly and reliably locate fire at the wildland-urban interface. Evaluation of the sensor network will be the responsibility of Dr. John Kim, the Technology Director and field and website staff working with him. Evaluation will focus on qualitative descriptions and tests of system infrastructure, reliability, and usability. Detailed descriptions of the cost and level of effort, installation techniques, photos, and other helpful information will be posted on the website as a “how to” manual for agencies and community groups interested in using this technology in other wildland-urban areas.

Community-based Fire Preparedness Program

The educational portion of the evaluation plan will address whether the web-based fire hazard model and other educational tools increase and sustain community awareness and preparedness. Dr. David Dozier, SDSU’s School of Communication, will work with the Social Science Research Lab to evaluate the community fire education program. He will follow a general communication program evaluation design specified in Broom and Dozier (1990, pp. 71-112) which blends the rigor of experimental design with data collected in field settings to maximize both internal and external validity of the evaluation (see Appendix for further details). The final report will address questions regarding the efficacy of types of communication media (e.g., technology), fire preparedness knowledge, attitudes towards risk and preparedness, and what new behaviors have community members adopted (see Appendix).

5.0 PROJECT FEASIBILITY

Technical Approach

We propose to create a fire-detection sensor network by installing 13 FireAlert Sensors, 3 weather stations, and 4 cameras onto an existing 802.11b wireless broadband network at SMER (Appendix Figure 1). The existing wireless network is comprised of 10 solar-powered telecommunication towers that collect data from in-situ sensors and transmit them to the Internet via a broadband wireless backbone. Fire and other sensors would be installed within line-of site of these existing towers. Sensor sites have been determined using a GIS viewshed analysis to maximize coverage of the wildland area (see Appendix for maps). Signals from the sensors travel over the existing telecommunication network to a reserve server. The server both notifies Emergency personnel via pagers and sends the data for processing to the SDSU server on campus. Personnel logging onto the SDSU server will see the location of the fire on a map, real-time weather data from the site, and video images (see Appendix for diagram). Here we describe core technologies of the communication system:

- FireAlert Sensors (proposed): Customized Solar Energy Collector and Solar Energy Management System allow the sensors to operate on solar power in remote locations for up to 20 years. The embedded logic provided by the Digital Control System controls the rotating carbon dioxide sensor to detect and validate an 8’ x 8’ wildfire signature within a ½ mile radius in less than 2 minutes, and transmit the position of the fire to an Internet accessible receiver using 900 Mhz radio signal.
- Weather Sensors (proposed): Standard meteorological sensor, plus fuel moisture and temperature will be connected to a Campbell data logger which is in turn connected to an IP-addressable computer.
- Cameras (proposed): Video images are connected to an axis camera server via an IP-addressable computer.
- SMER Network (existing): The wireless sensor network at Santa Margarita Ecological Reserve (SMER) consists of 10 Telecommunications Sites (TCS) and a diverse suite of environmental sensors that stream real-time data to the World Wide Web via the TCS. The TCS uses 802.11b technology and a variety of external antennas and amplifiers to create a communication bubble that covers over 65% the reserve which enables efficient and flexible placement and configuration of environmental sensors. Weather station sensors and IQEye cameras are currently in operation on the network (see Appendix for examples). FireAlert has been tested and confirmed to work on the network.
- Internet Access (existing): The SMER Network gains access to the Internet via the High Performance Wireless Research and Education Network (HPWREN), a non-commercial, wide-area wireless backbone network that connects remote backcountry locations across Southern California to an Internet node at University of California, San Diego (see Appendix). HPWREN is an NSF-funded project lead by the San Diego Super Computer Center and Scripps Institution of Oceanography, along with a multitude of collaborating institutions. HPWREN provides a 45-Mbps bandwidth, allowing for simultaneous transmission of various real-time data, including voice and video, in unprecedented quantities.
- Pager Access (proposed): Advanced Host Monitor, by KS-Soft, is a popular, commercially available software that monitors network connections and services. It can be configured to monitor messages sent transmitted by FireAlert Fire Sensors and automatically dial pagers held by emergency response personnel using the computer’s modem.

- High-volume Server (existing): The server is housed at the SDSU visualization Center. SDSU Viz Center is designed to disseminate massive amounts of data simultaneously, and is fully capable of accommodating millions of web access requests per day during and emergency. The Visualization Center is equipped with Wide Area Visualization Solution (WAVS), developed by TeraBurst Networks, Inc. WAVS is comprised of two major Sun Microsystems machines, a Sun Zulu graphics server and a 16-CPU Blade Server, connected to the Internet trunk at the San Diego Supercomputer Center by optical switches and a 2.5 gigabits-per-second optical fiber network.

Interoperability

The Data Server at SMER will gather real-time data from various sensors and will transmit the data to the High-Volume Webserver at the SDSU Visualization Center using a secure file transfer protocol. Any webserver on the Internet with properly authenticated identification would be able to receive the same data. The estimated fire location and weather maps will be disseminated over the Internet as web pages.

Technical Alternatives

Our project relies solely on existing infrastructure for its network facilities. The wireless communication bubble at SMER has been in operation since 2000. HPWREN provides the sensor network with a high-speed wireless Internet connection. The SDSU Visualization Center's high-volume connection to the Internet easily allows for enormous amounts of intense traffic expected on the website during an emergency. Instead, our project focuses on how these networks can best be used to increase fire safety.

Maintenance and Sustainability

The technological and educational infrastructures of the project are anticipated to persist well after the completion of formal project funding in 2007. All sensors being installed have low-maintenance requirements. The sensors and supporting telecommunication network will be maintained by SMER field station staff as part of their facility and data management program. The Fallbrook Fire Safe Council will continue to provide information about the network and fire preparedness through their volunteer program developed during this project.

Scalability

The purpose of this project is to provide a scalable model for expanding fire sensor detection areas into the backcountry and wildland-urban interface areas of the country. Because the sensors can also be connected to the Internet via satellite connections, they can be installed wherever satellite connections are available. We also have the capacity to expand the existing Fallbrook demonstration site. We are working with partners at UC San Diego and Camp Pendleton Marine Corps Base to extend the SMER sensor network 20 miles westward through the Fallbrook Public Utility District lands and onto Camp Pendleton Marine Corps Base. Once these telecommunication stations are in place, additional sensors can be installed to enlarge the fire detection area.

Applicant Qualifications

Our team is uniquely qualified to implement the project (see Appendix for further details). Staff and technicians have already established the 802.11b telecommunication network, maintain and operate a variety of sensors on the network. Scripps Institute of Oceanography, a graduate school of UC San Diego, has installed weather stations on the wireless network and is currently streaming data to its servers at UC San Diego. Our technical director, programming staff, and the SDSU Visualization Center have been developing databases, interactive clickable interfaces, automatically generated quick-time movies, and others and are on the forefront of developing innovative interactive formats for learning. The Fallbrook Fire Safe Council has a short but strong track record in planning and carrying out fire safe activities in the community and Mission Resource Conservation District has a 20-year history of working with community partners on environmental issues. Combined with the experience of our vendor at Ambient Control Systems, Inc. we have assembled an impressive team, fully capable of meeting the challenges of the project.

Project Implementation and Completion

The project will be implemented in two general phases: (1) sensor installation and website development will predominantly occur during the first and second years, and (2) end-user support through the technical training and education programs during the 2nd and 3rd years. Our project plan calls for implementation of sensor hardware, other equipment, and database development within the first year of the award. We have allotted time for preparation, installation, development and training. Our web development team will work in parallel effort to build first the web page for the Emergency Command Center and other emergency personnel, and then further develop these displays for the public website. The Community Education Program will start during the first year to insure that a rigorous outreach program is underway when the website goes on-line. Please see our breakdown of the project timeline in the Appendix.

Privacy and Security

As part of our camera installation procedures, we will examine the field of view to avoid invading the privacy. The 4 digital cameras will be focused on Interstate 15 and will not view any homes or other areas where individuals have a reasonable expectation of privacy. Other sensors will not be a problem, since neither the FireAlert sensors nor weather stations use visual or sound cues to take measurements. No recognizable images of the public will be made available on the public website.

Dissemination

Dissemination of the information about this project will be provided on the web-site and through the education program, and presentations at 2 national meetings. The website will contain a “how-to” manual with photos detailing the set-up, maintenance, operation, outputs, reliability and costs of the fire detection and hazard network. Local citizens will learn about the project through the community education program. Project, Technical, Education and Visualization Center Directors of the project will attend and give presentations at community and agency meetings. In addition, we have budgeted two meetings for Directors in the project to present our findings at State and National meetings. Examples of National meetings to attend include Wildland/Urban Interface Fire Education Conference, Tall Timbers Fire Conference, ESRI Conference.